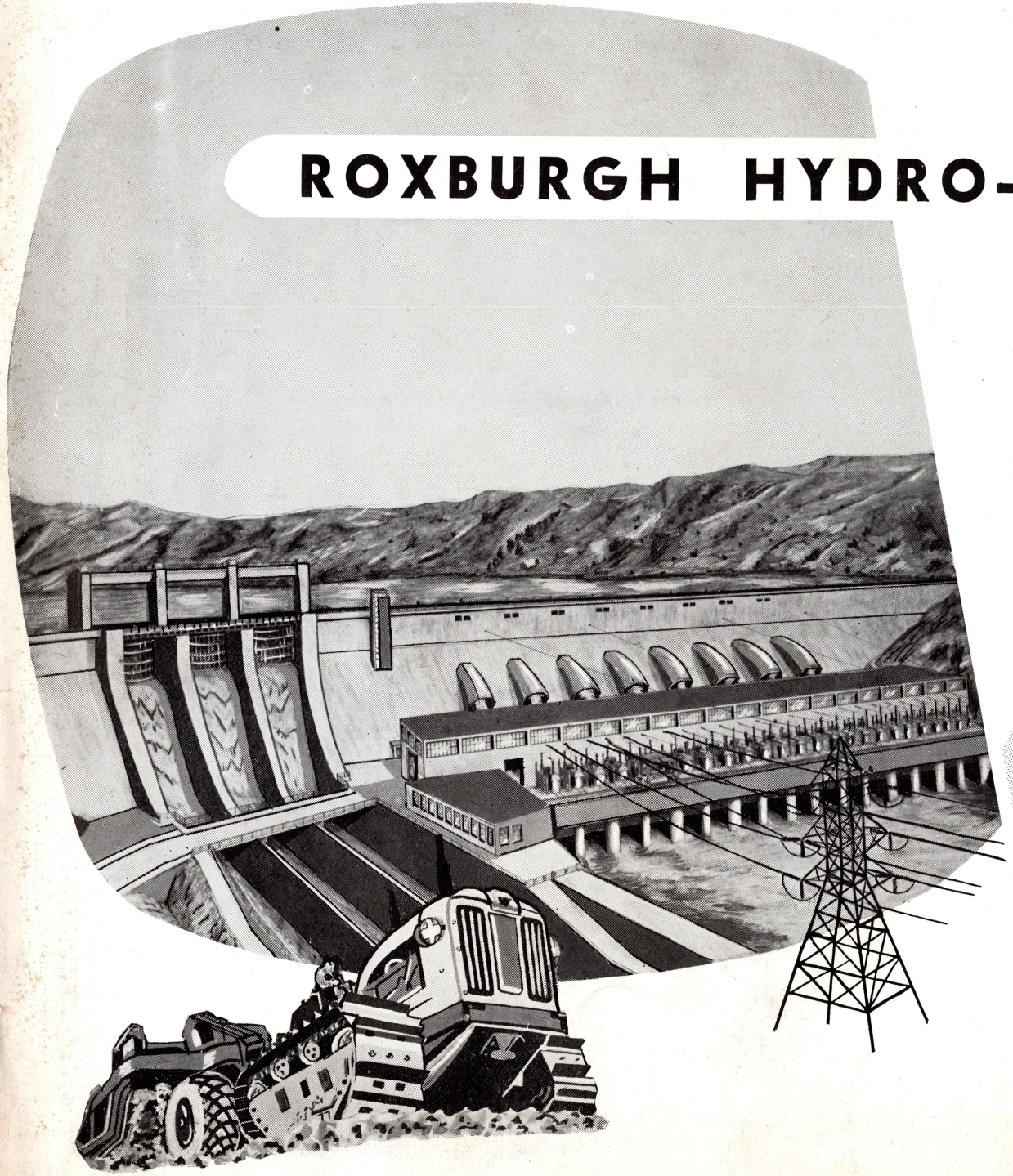
CENTRAL OTAGO • NEW ZEALAND

ROXBURGH HYDRO-ELECTRIC PROJECT



Introducing New Zealand's greatest hydro-electric project and the biggest engineering task ever undertaken in the Dominion. Designed to produce 320,000 kilowatts of power for the South Island grid system, Roxburgh Gorge may involve a total capital cost of £24,000,000. By harnessing the mighty Clutha River, it will provide power for southern industries and homes for many years to come.

"The Evening Star Co. Ltd."

FOREWORD

By Project Manager

Civil engineering contracting for heavy construction cannot be a one-man job. As told in story and illustration in this excellent publication we see the Roxburgh Gorge Power Project unfolding as New Zealand's largest concrete structure, built across the path of our biggest river, now well on the way towards completion. It is the combined result of the work of many people.

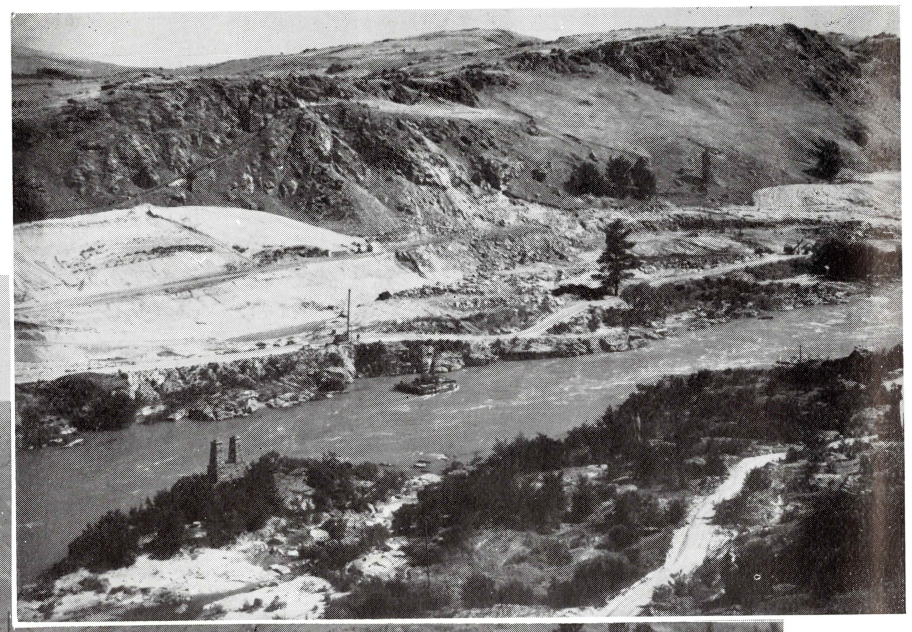
Construction has proved exacting. It has involved the diversion of a large volume of swiftly-flowing water; the excavation of thousands of cubic yards of rock; the challenge of the gullet; the transport and assembly of materials; the placing of hundreds of thousands of cubic yards of concrete; the magnitude of dam formwork; the intricacies of power-house construction under conditions of extreme exactitude; the steel erection, reinforcing and placing; and the host of supplies and services that must be organised in advance of achievement.

Supervisory staff and labour have been equal to all demands. Construction of the project is the particular task of the contractor, but we must remember that the completion of the Roxburgh Power Project is the result of the efforts of many groups. Investigation, exploration, survey and design are the province of the Ministry of Works, and this Department continues its interest through the inspection of work and the measurement of progress achieved. Many sub-contractors provide specialist services and supplies in fields which are outside normal civil engineering activity, and the State Hydro-electricity Department will complete the mechanical installation which will spark the end result of all our Labour.

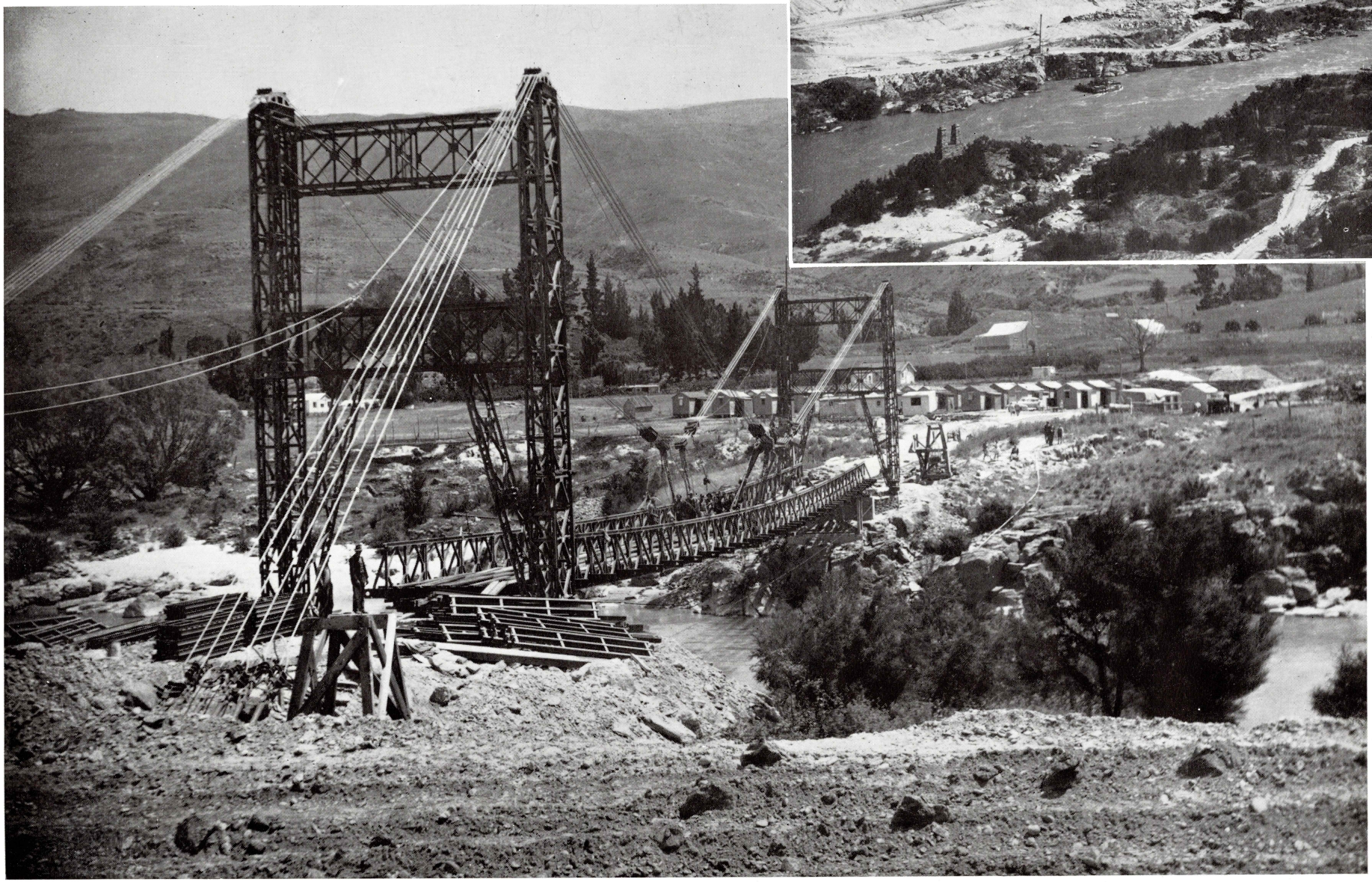
F. J. Handcock,
Project Manager, Cubitts, Zschokke, Downer.

WHEN THE CLUTHA'S FLOW WAS STILL UNIMPEDED.—An aerial view of the site of the great scheme in 1951 with the diversion channel (centre foreground) substantially completed and the three major townships for the workmen laid out in the middle distance.

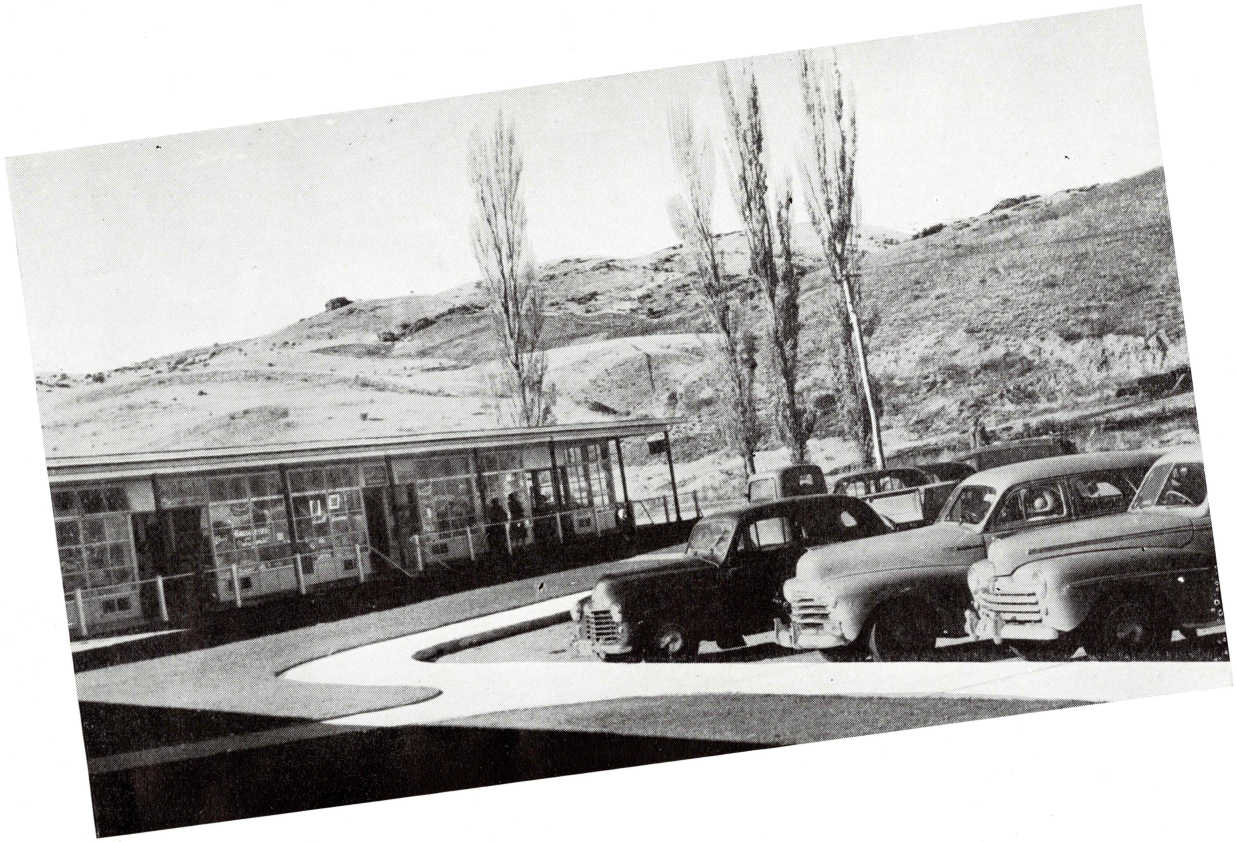
Right.—THE WILD AND RUGGED LANDSCAPE through which the river flowed as it appeared at the time of the preliminary investigation to determine whether the site was suitable for the massive dam and giant generating station.



Below.—ONE OF THE FIRST TASKS was to throw a Bailey Bridge across the Clutha some distance below the scene of major construction in order to provide quick access to the extensive temporary settlements.



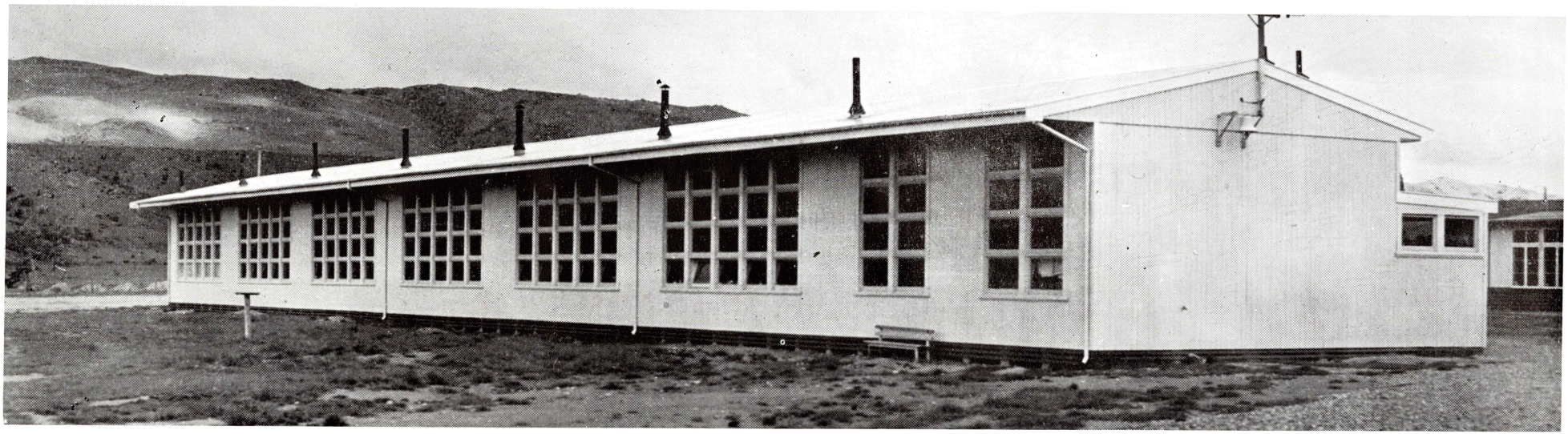
POWERFUL CONSTRUCTION EQUIPMENT was assembled from several countries on the other side of the world. A remarkable collection of heavy-duty trucks and earth-moving machinery contributed a full share to the busy aspect of the site. In August, 1955, these British trucks, their Roxburgh duties done, were driven away to Canterbury to another important project.

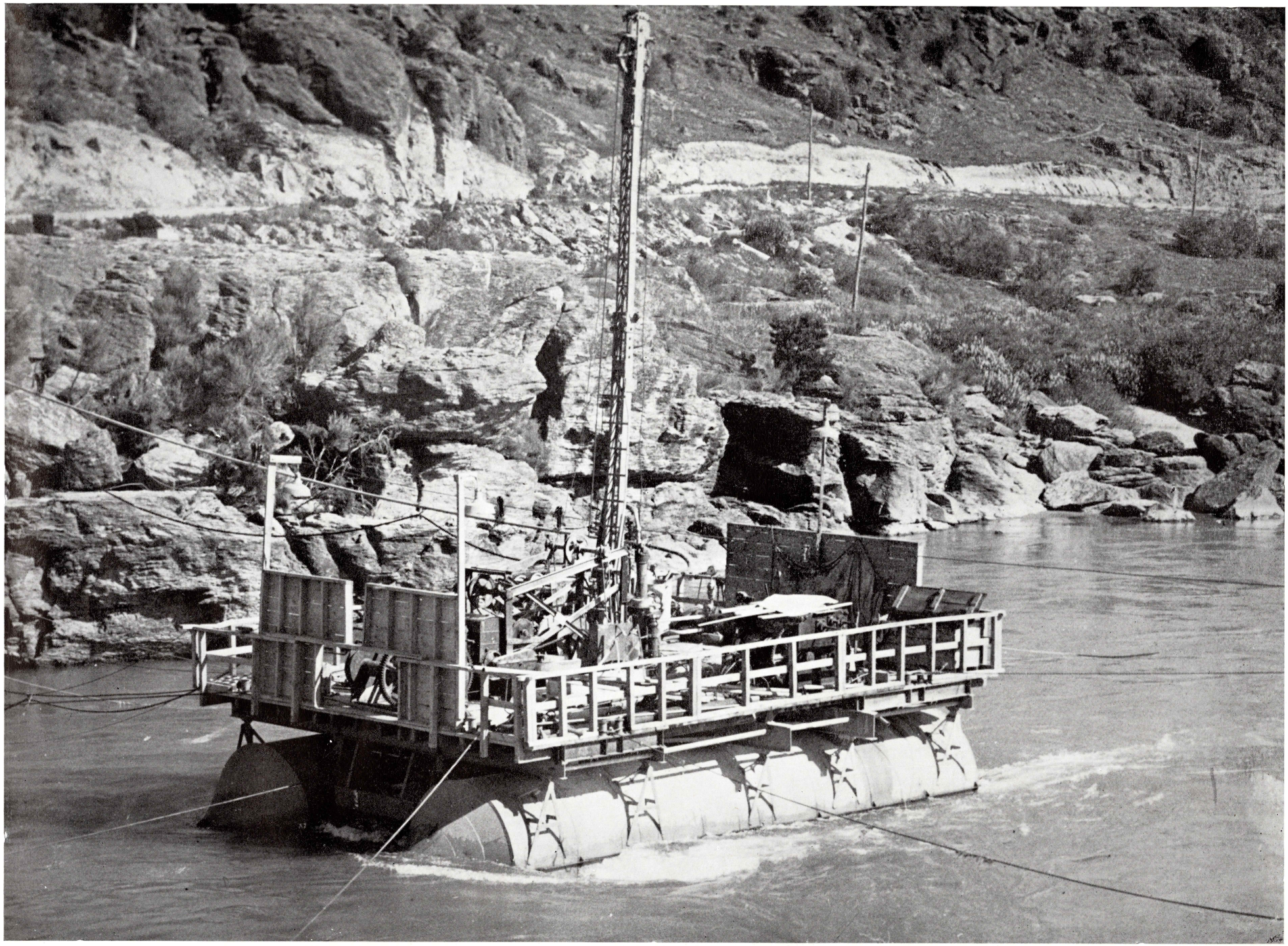


LEFT.—In the rugged Central Otago country this modernistic shopping centre provided a striking contrast to the shanty stores which sprang up in this same region in the days of the gold rush nearly 100 years before.

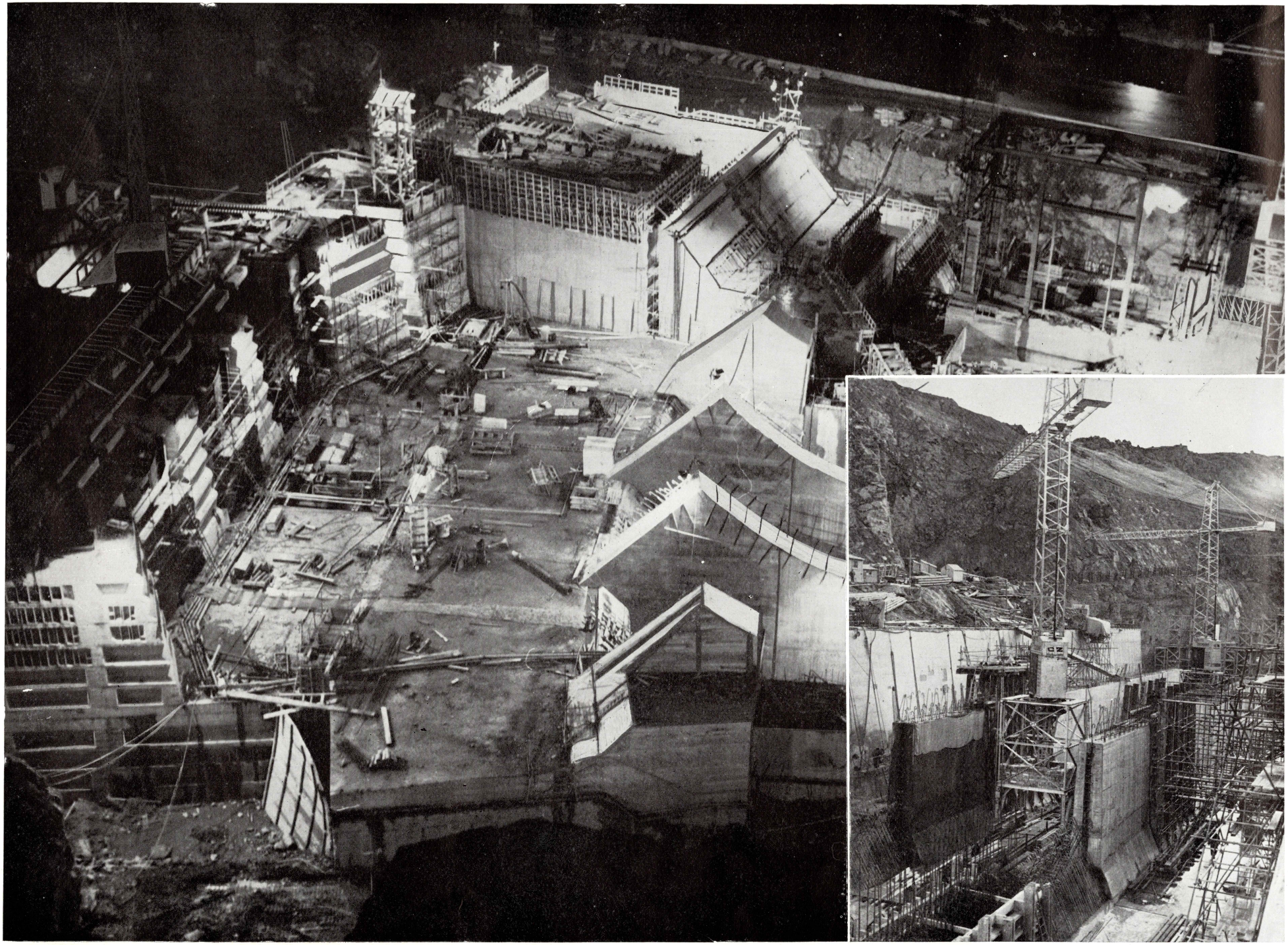
FOR CENTURIES New Zealand's mightiest river had flowed purposefully between high banks on its way to the sea without puny man attempting any other interference than plumbing its depths with dredges in search of gold. Then came engineers and surveyors to plan a great scheme to wring energy from the flowing water. Later still came the workmen who were to provide the manpower. The first gangs were mostly New Zealanders, transferred from other public works. Then came Britishers, Dutch from Indonesia and the Netherlands itself, and men and women from many European lands; all to contribute their part and work in harmony until the project resembled a miniature United Nations in which all played a worthy part.

BELOW.—The authorities were determined that the workmen on the big hydro-electric project should not suffer pioneering hardships on the job. Our picture shows the attractive and well-windowed school that was built before the workmen arrived with their wives and families.



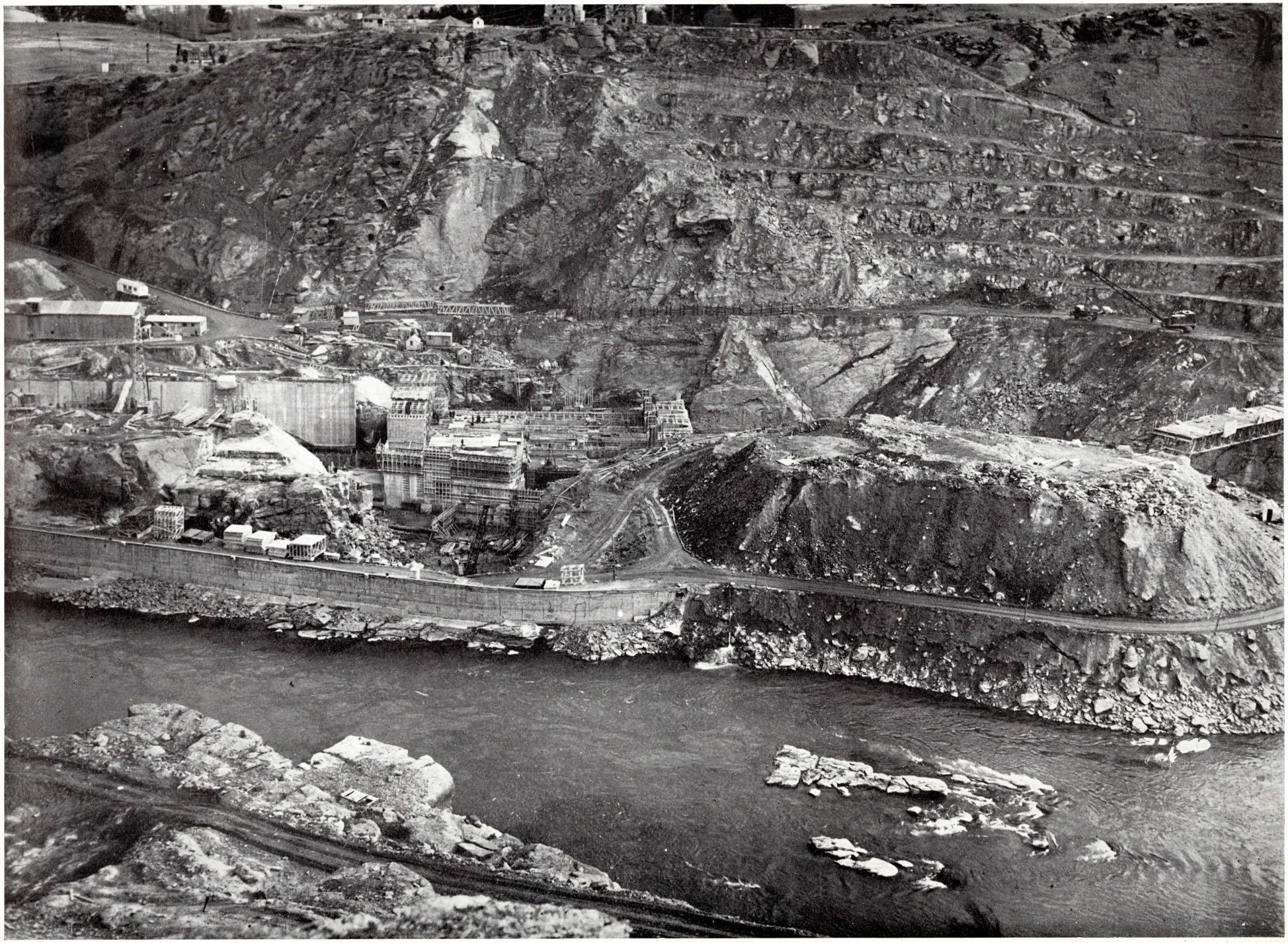


THIS GROUTING PONTOON was built and launched on the river to consolidate the river gravels thus forming an impervious curtain for the coffer dams.



ABOVE.—As concreting of the dam structure proceeded in earnest the work went on night and day. In the hours of darkness floodlamps illuminated the busy scene, as, for instance, this area over the diversion channel, divided into three free-flowing sections.

Before the river flow could be admitted to the diversion channel special smooth-finishing concrete lining and section walls had to be built amid this forest of scaffolding and steel reinforcing rods.



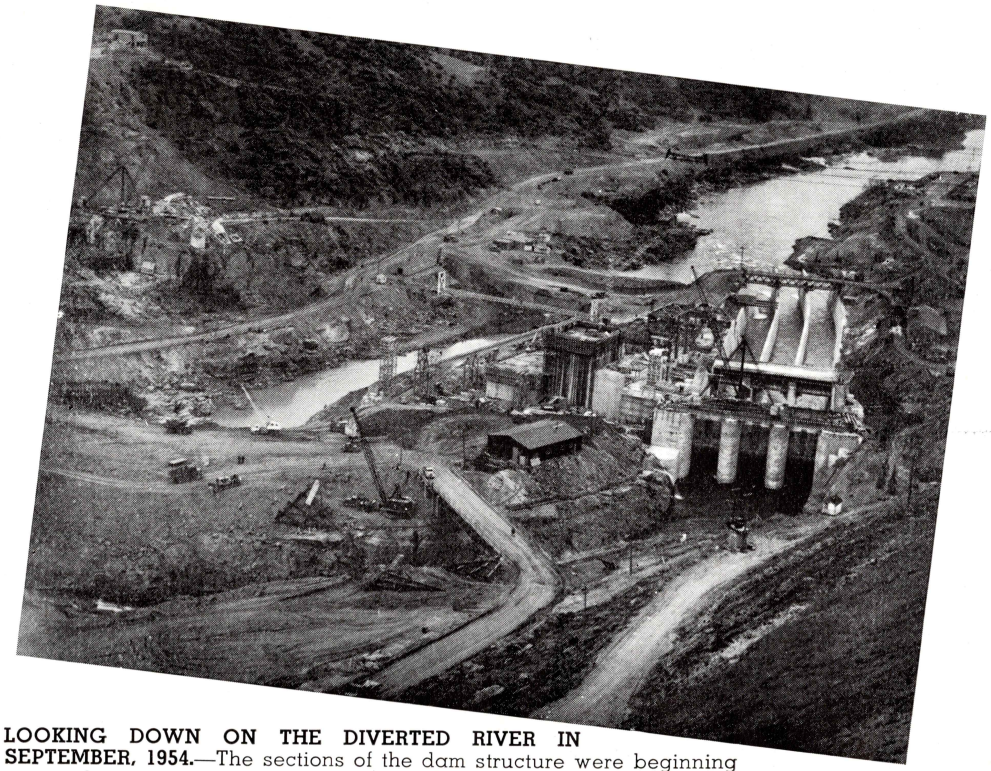
IN PREPARATION FOR DIVERTING THE CLUTHA, great piles of rock and other rubble were assembled in readiness for creating a coffer dam. The material come from the diversion cut and from terracing the rocky hillsides.

UP GO THE EXPLOSIVE CHARGES and the river placidly accepts its new course This was the moment for which all had been waiting. The diversion was postponed from the winter of 1953 to 1954 as a result of delays after the Ministry of Works handed over the job to the overseas contractors, Holland, Hannen, and Cubitts, of England, and Zschokke Ltd., of Switzerland. Later, the New Zealand company of Downer & Co. was added in a new contract and the work was then undertaken under the name of Cubitts, Zschokke, and Downer.

The Diversion . . .
. . . Is Complete

The anxiously-waiting people of the South Island sighed with relief when they learned that the diversion of the Clutha had been safely accomplished. This was widely regarded as the trickiest part of the task and wiseacres had predicted serious trouble at this stage.

Such a mammoth task as damming and diverting the Clutha River had never previously been undertaken in New Zealand and many people were sceptical that it could be done successfully. At a very early stage in the project, the then Minister of Works, the late Mr Semple, admitted that the big river " gave him the creeps."



LOOKING DOWN ON THE DIVERTED RIVER IN SEPTEMBER, 1954.—The sections of the dam structure were beginning to rise beside the diversion channel.

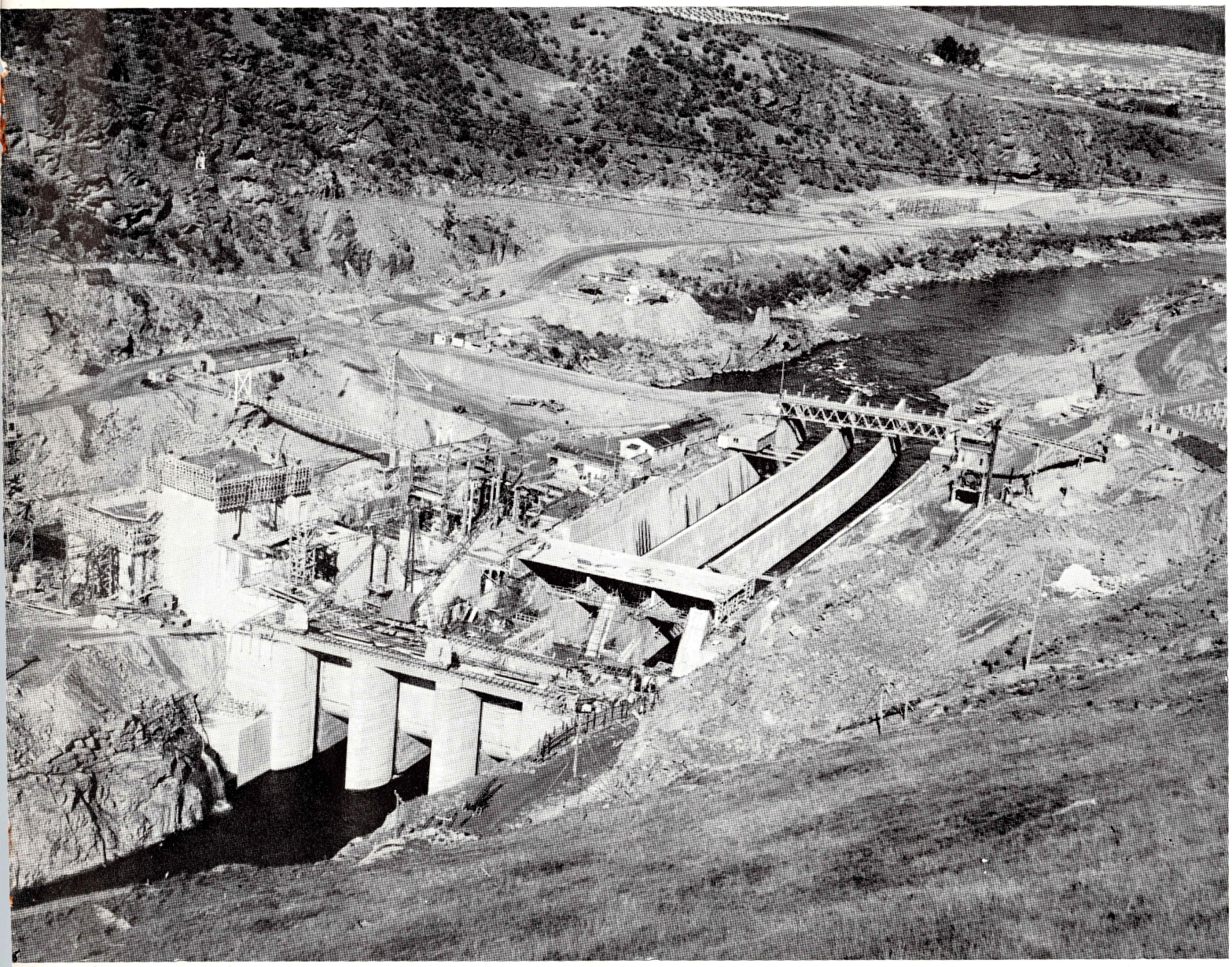
In the end the river submitted with surprisingly little fuss. On July 1, 1954, the fuses of the charge in the narrow walls leading into and out of the diversion channel were blown and water began to flow through. All the men and equipment at the scheme were poised ready to push great quantities of rock into the original river bed.

At first the swiftly-moving water washed considerable amounts of the rubble downstream, but as quantities mounted the battle was gradually won. In less than 24 hours the original channel of the river was sealed off and the diversion was carrying the full flow.

Many months were to pass before the enclosed section of the river bed could be pumped dry and the loose rock in the sweep for the dam excavated down to the firm, natural foundation. A fault, or gullet, ran across the river at this point and there was much speculation whether gold would be recovered. Only " colours " of less than commercial importance could be washed from the bed of the gullet. In any case the contractors were too anxious to get on with the job to bother about recovery of gold.

The diversion of the river brought about a new spirit of eagerness and enterprise at Roxburgh. The task became a competition with time itself. The contractors stand to benefit financially if they finish the scheme ahead of schedule. The men themselves are eager to show what they can do in hastening the turning of the generators to bring abundance of electrical energy to the South Island where it is becoming critically short.

BY AUGUST, 1954, the pattern of the great scheme was becoming more apparent. Excavations into the hillsides on either side of the river were proceeding to provide foundations for the structure that is to rise 160ft above normal river level and dam the river as far back as the town of Alexandra, 20 miles away.



From the giant batching plants great quantities of concrete were run out on overhead cableways — (known as flying foxes)— and the tempo of pouring continued at an ever-increasing rate. Records were broken almost weekly, with thousands of cubic yards of concrete added to a growing and impressive total.

MAN CHALLENGES NATURE'S FORCES

In many ways the Roxburgh Gorge project symbolises New Zealand's arrival at adulthood. At earlier stages of the Dominion's development the engineers were content to undertake smaller projects which met the needs of the moment and which did not involve too great a battle with the forces of Nature. At Roxburgh Gorge they set out to tame the mightiest river in the country and to create what will be the biggest hydro-electric scheme in the Southern Hemisphere for some years at least.

The scheme was first conceived before the Second World War diverted the planning capacity of the country to a struggle for sheer survival. But with the turning of the tide of war the prospective shortage of electric power for the South Island forced consideration of the next scheme which would be undertaken after the full capacity of Waitaki and other subsidiary stations was absorbed.

It was in 1944 that the people first learned that a hydro-electric scheme was being planned on the Clutha River near Roxburgh. It became known that the engineers of the Ministry of Works favoured a site about six miles upstream from the town of Roxburgh at a point known as Coal Creek because of the coal deposits there which had been exploited for many years.

Finally, in 1946, the then Minister of Works, the late Mr R. Semple, announced that the Government had approved of the construction of a 320,000 kilowatt station on the Clutha River above Roxburgh. The site chosen in 1949 was known as Tamblyn's Orchard, where the river emerged from high, narrow banks to a comparative plain.

It was well known that the southern part of New Zealand offered great possibilities for electrical development, and Mr Semple pointed out that three-quarters of New Zealand's potential hydro-electric energy existed in the South Island and three-quarters of that percentage in the Province of Otago. Almost for the first time a Cabinet Minister went on record as saying that if industries wanted to be certain of ample electric power they must consider setting up in, or moving to, the South Island.

The people in the south were at once eager for the work to begin, but it was not until 1949 that it seemed as if the scheme was really starting. Much energy had to be absorbed in carefully testing the chosen site and in erecting housing settlements for the estimated 3,000 people who would live nearby while the work was in progress.

Ever so slowly the scheme took shape. Equipment was brought from various countries overseas and the Ministry's store was searched for suitable plant that could be diverted from other projects. The need for national development in various fields was a drain on finance, equipment and manpower.

It was not a task which could be undertaken lightly. No other project in the history of the country had presented so many problems. The Clutha River is a fearsome monster that drains three huge lakes and a vast area of countryside. Even in its most placid reaches it commands respect. Between Roxburgh and Alexandra and in the Kawarau Gorge it boils violently through precipitous country. It can rise 10 or 20ft almost overnight after heavy rain and in the gold dredging days men learned to fear its moods.

The engineers decided to cut a diversion channel alongside the existing bed and build the sluiceways in that new path. The channel would in the end be used as the spillway for the completed scheme, great steel gates being suspended in the three sections of the diversion channel to control the outflow when the river exceeded the electrical needs of the district served.

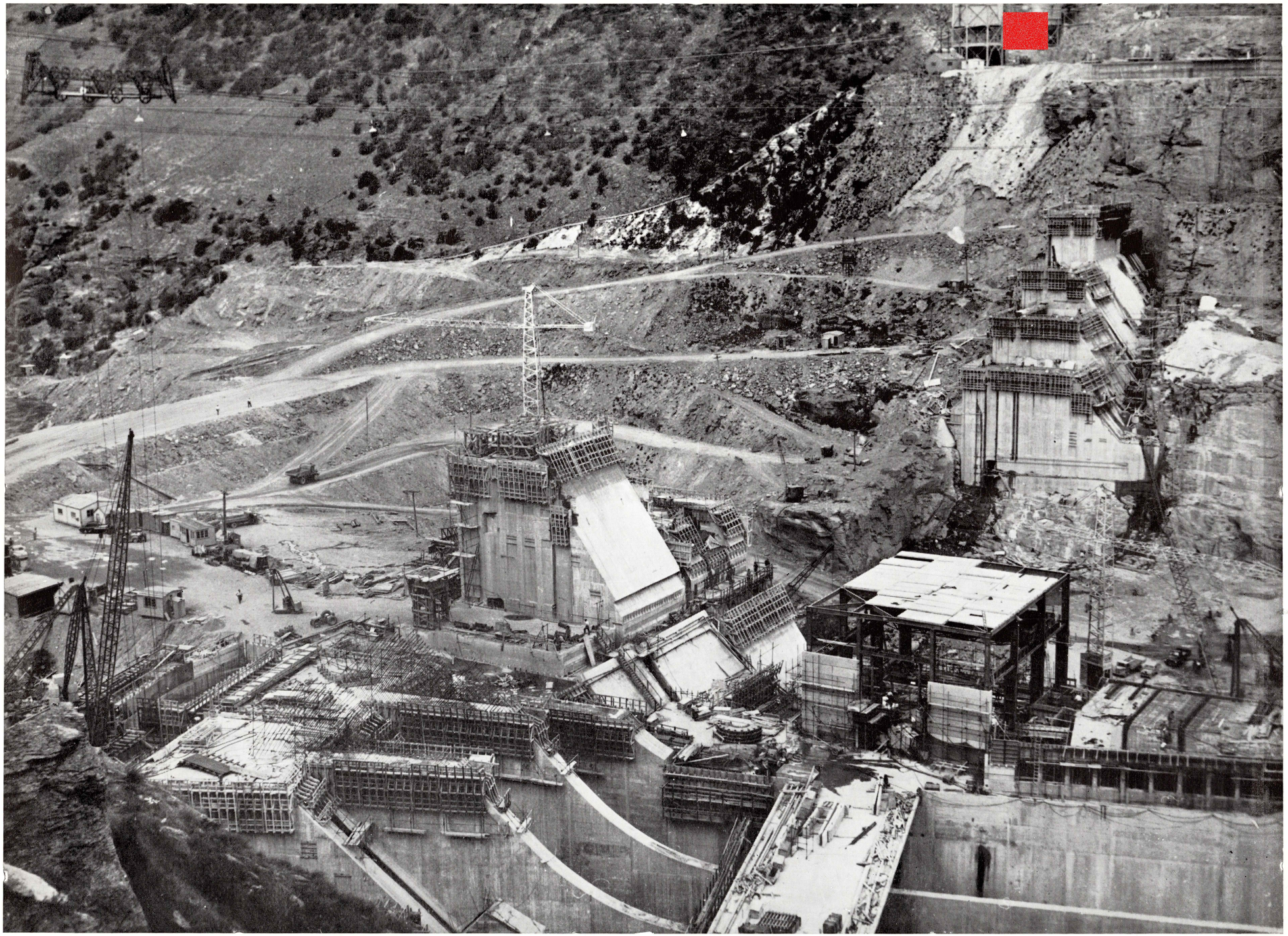
Everyone concerned agreed that the diversion was the most critical of the undertaking and, as has been shown on a previous page, that task was triumphantly completed, but only after delays and disappointments. Since that section of the project was done, the work has proceeded by leaps and bounds, and everyone concerned is confident that the scheme will be finished and brought into operation before the revised schedule which was adopted after delays had set back the original timetable.

Allied with the construction of the dam and the power station are other major undertakings. Control of the outlets of the lakes feeding the station are an important factor in ensuring its success because in the South Island of New Zealand the winter period of maximum demand for electricity coincides with the season of minimum river flow when the watershed is iced over. Much control of Lakes Wakatipu and Wanaka is out of the question because of sizeable townships close to normal lake level, but at Lake Hawea a dam is being built to raise the lake by 50ft. This will provide a vast amount of water to boost normal river flows during the winter months.

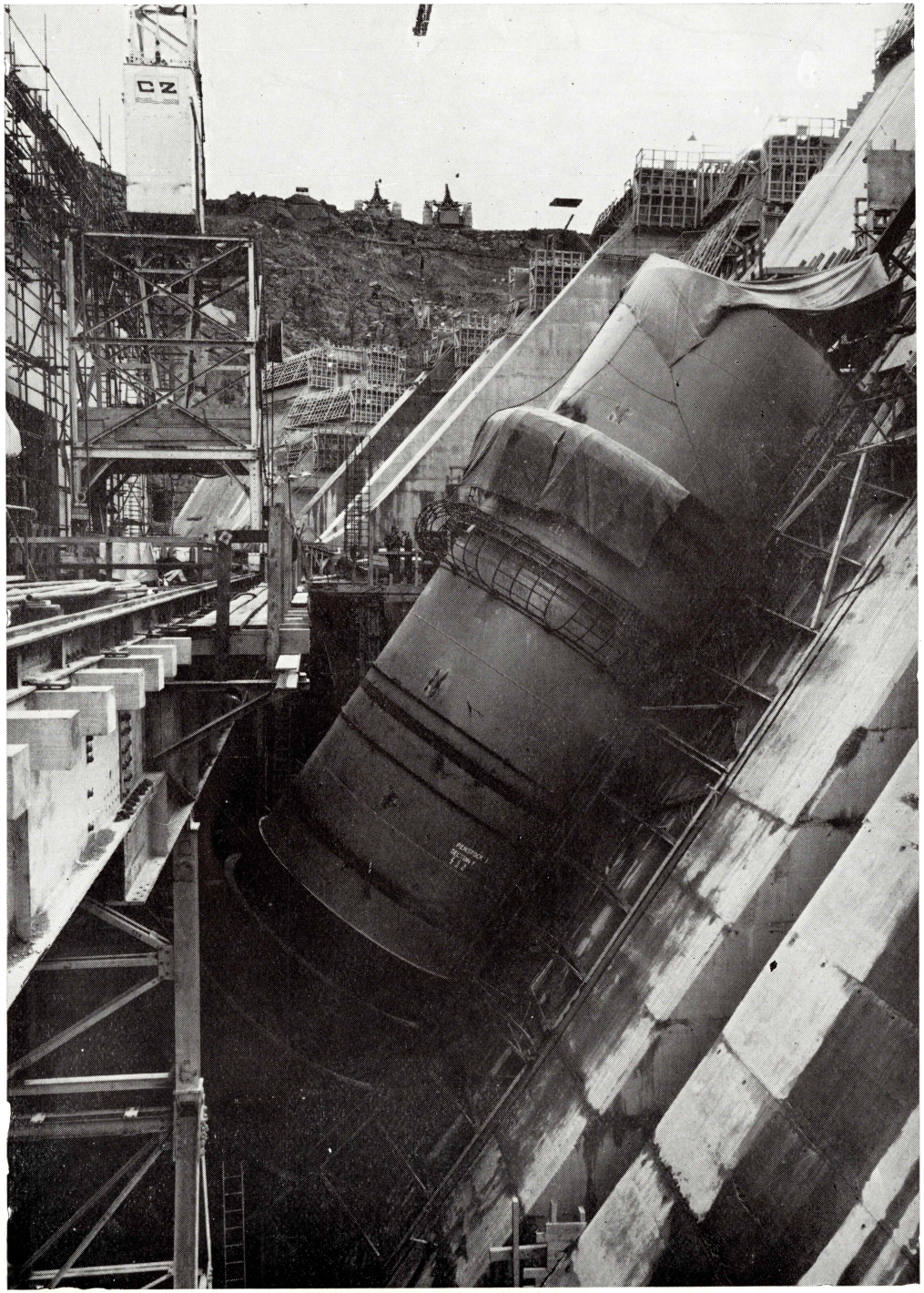
Great transmission lines have been built to carry the power from Roxburgh Gorge to the principal centres of population. One leads directly over high country towards Christchurch, and another will take power to Dunedin. Both of these centres have a rapidly increasing demand for power and Dunedin's own Waipori station of 42,000 kilowatts is already quite inadequate to meet peak requirements.

In its final development Roxburgh Gorge will have installed eight turbine generators, each supplying 40,000 kilowatts—giving a total capacity of 320,000 kilowatts, which is considerably more than the present total consumption of the South Island. But at the rate of rising demand all the power from Roxburgh will be absorbed within about 10 years. This station is far bigger than any possible in the North Island, but it will be exceeded in size by Benmore on the Waitaki River, the next step in the chain, which is expected to produce 340,000 kilowatts.

Power stations on this scale are expensive. Roxburgh is estimated to cost £24,000,000 when finished, the greatest single individual undertaking in the country.



THIS WAS THE APPEARANCE OF THE DAM STRUCTURE IN JANUARY, 1955. The gap between the concrete structure in the centre and those at the right was caused by the need to drain and excavate the original bed of the river.



A CLOSE-UP VIEW OF ONE OF THE PENSTOCKS leading down to No. 1 generator. Men are dwarfed by its great dimensions. Water under great pressure will flow down this 180in diameter tube to the turbine.

Massive Structures In Steel

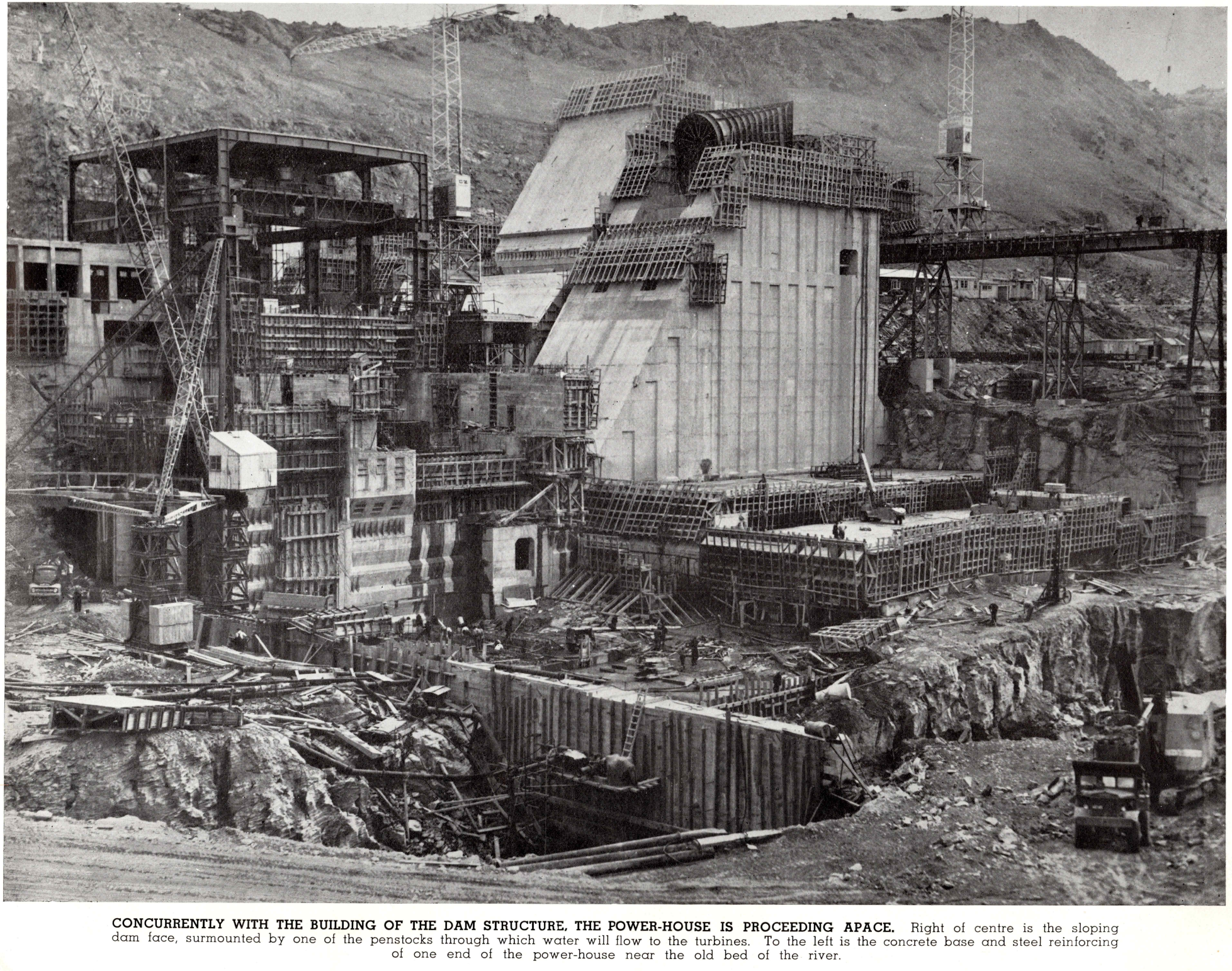
Simultaneously with the great concrete construction at Roxburgh, important items in steel for the hydro plant have been building about 100 miles away. A large proportion of the steel work for the Roxburgh contract has been fabricated by the Dunedin and Port Chalmers works of the Fletcher Steel and Engineering Companies Limited. This work has been to the highest of engineering standards and is a credit to the company.

The penstock contract has introduced the first application of the fully-automatic submerged-arc welding process to this country. In the welding of the 1,600 tons of steel to form the eight penstocks, each 15 feet in diameter, the welding has been examined by X-rays to prove that a weld purity of 98 per cent. minimum has been attained. Plates for this work were edge-prepared and rolled at Port Chalmers and Dunedin and assembled, welded, and painted at a workshop set up at Roxburgh hydro where up to 80 men were employed at the peak period. Final alignment and welding on the dam is also being carried out by the company's engineers.

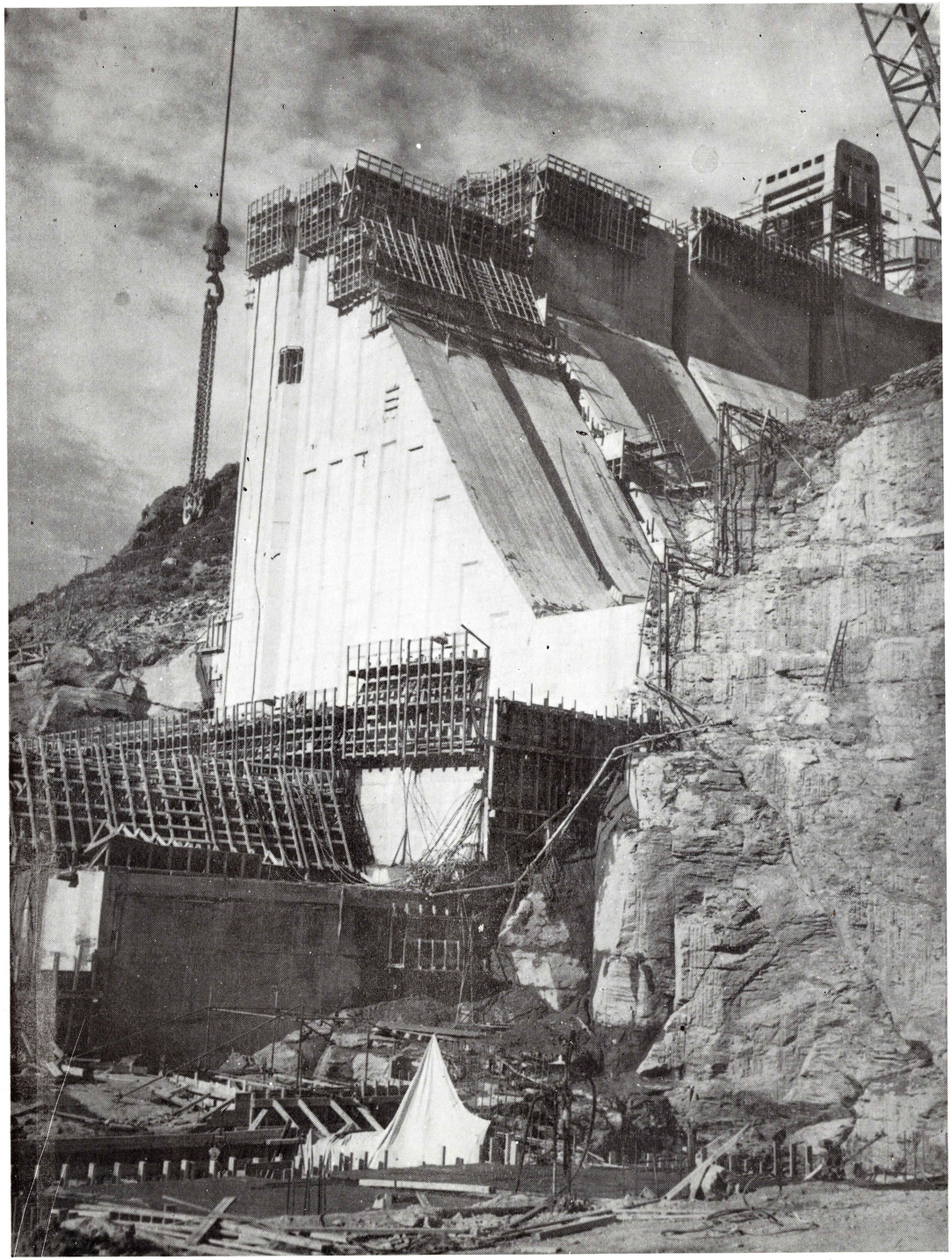
The intake gate-lifting cylinders made at Port Chalmers have been constructed to the highest machine-shop accuracies and have been tested to a pressure of 2,000lb to the square inch. These cylinders have a wall thickness of one inch and are 21 feet long.

The power-house steelwork, comprising 750 tons, has been fabricated in Dunedin and is now supporting the massive 200-ton crane at the site. This building is 60ft high from the base of the columns, 62ft wide and 500ft long.

In addition, spillway gate winches, stoplock gates, and many smaller items of steelwork are being supplied to contract.



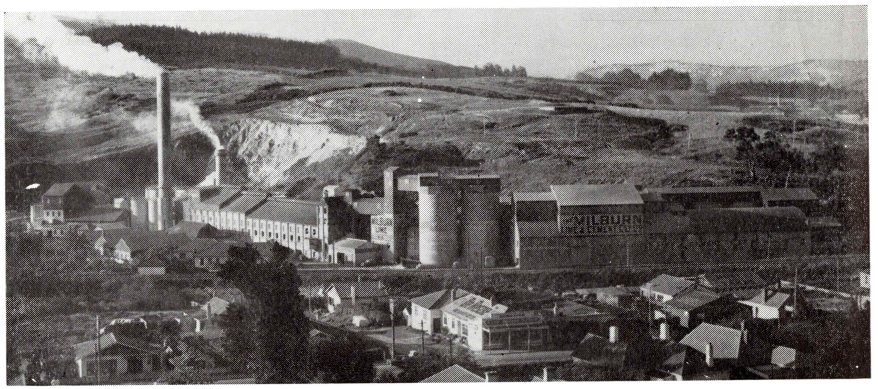
CONCURRENTLY WITH THE BUILDING OF THE DAM STRUCTURE, THE POWER-HOUSE IS PROCEEDING APACE. Right of centre is the sloping dam face, surmounted by one of the penstocks through which water will flow to the turbines. To the left is the concrete base and steel reinforcing of one end of the power-house near the old bed of the river.



Cement for Great Project

Perhaps the greatest effort called for in another industry associated with the Roxburgh Project has been in the supply of cement. Satisfying this need for the biggest single piece of concrete construction in New Zealand's history has been the task of the Milburn Lime and Cement Company, an organisation which has a long record of service to the construction industry of the Dominion.

The Milburn works at Burnside, five miles from the city of Dunedin, have been equal to all the demands made on them, in spite of the fact that the cement required for Roxburgh represents more than the total output of the works for two complete years under the old scale of production. A major expansion of the works had to be undertaken because of the hydro-electric scheme and the enlarged plant has been able to keep the batching plants at Roxburgh working at full capacity.

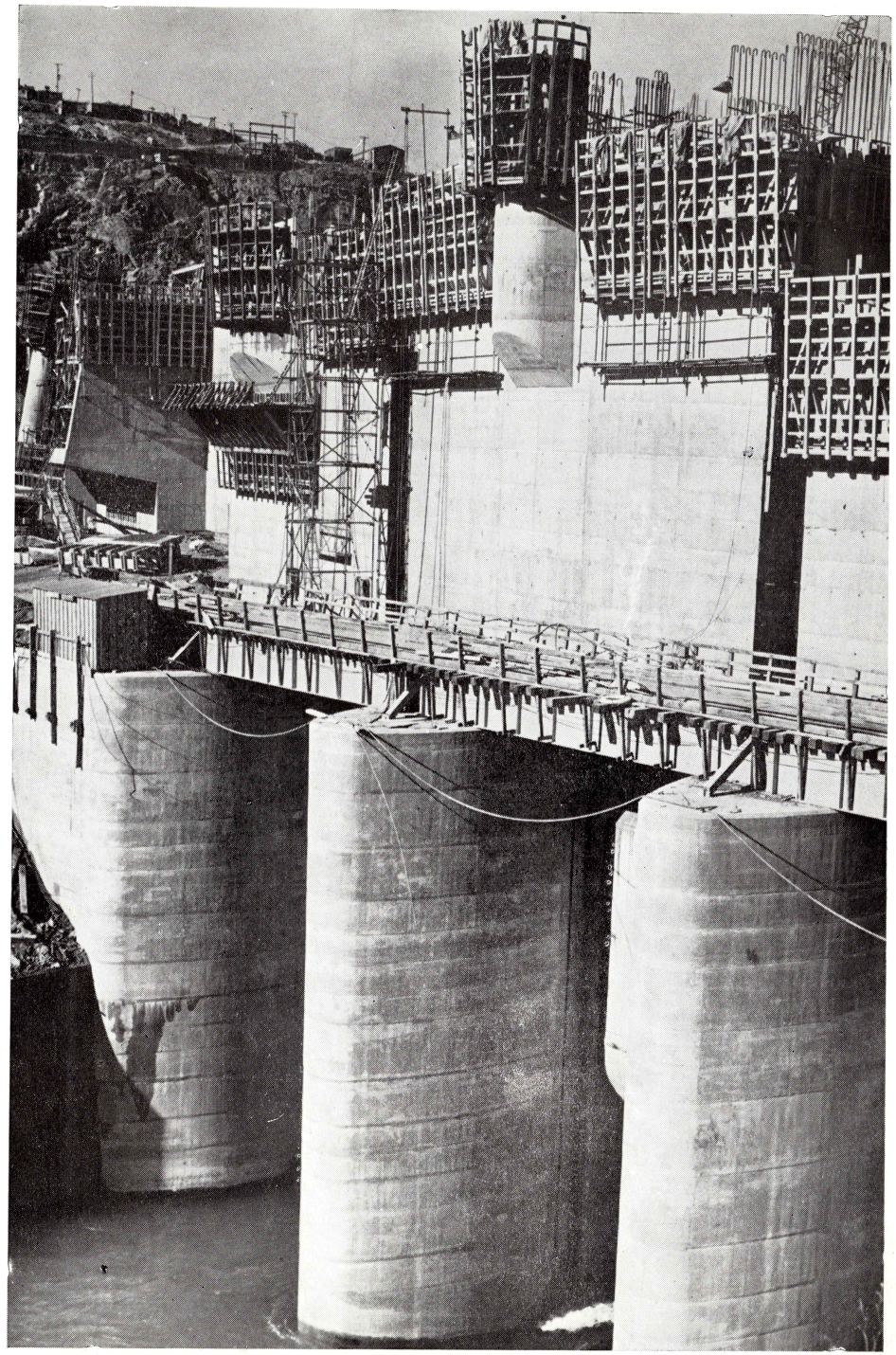


THE BOLD AND FREE LINES of modern design make a symphony in concrete which is now beginning to take shape. **The smooth surfaces of the dam sections** are impressive in their grace and simplicity, giving a sense of majestic power.

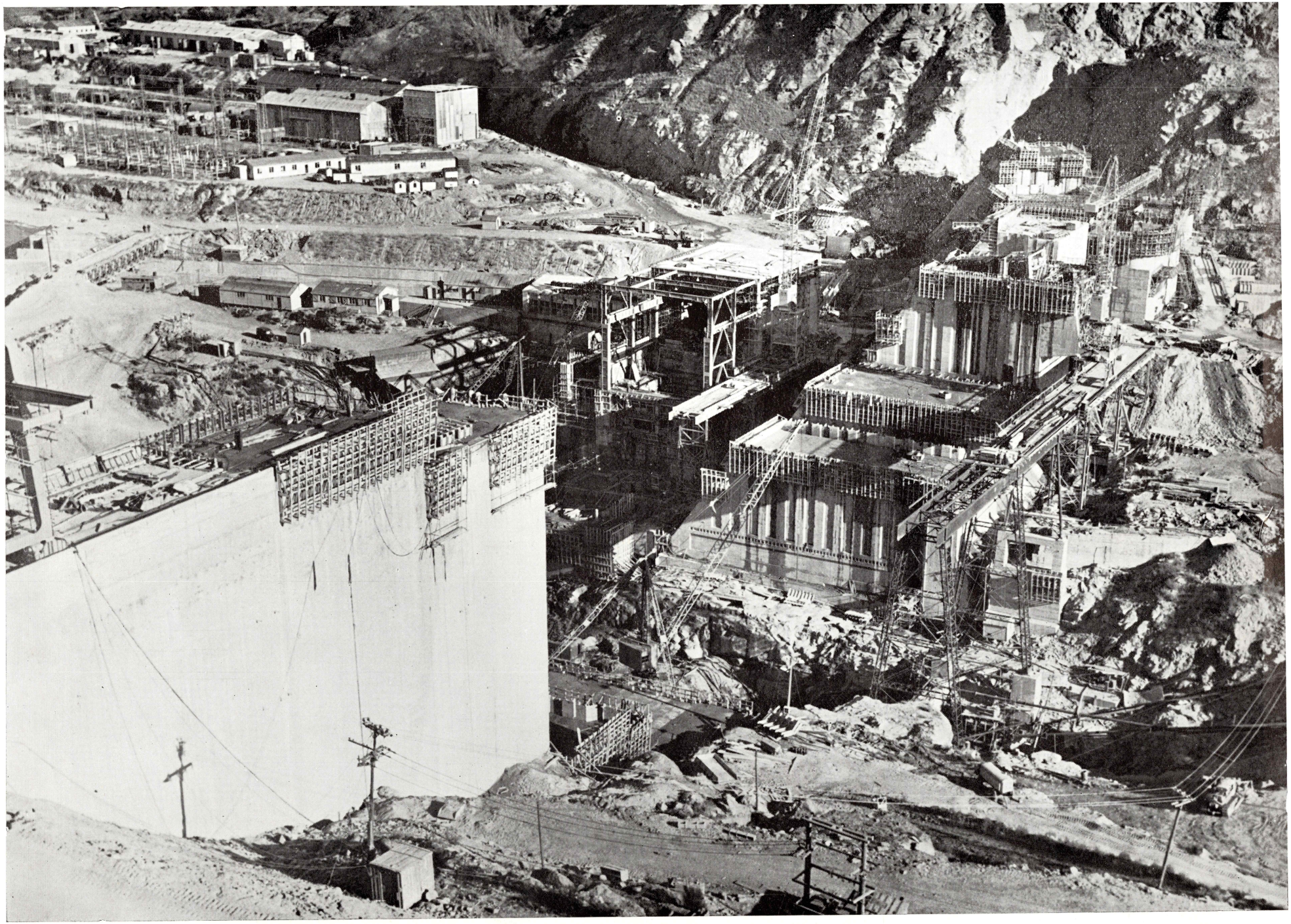
The toughest part of this task has now been completed. Up to the end of July, 1955, 80,000 tons of cement had been sent to Roxburgh. The orders for the remainder of the scheme then stood at a further 35,000 tons, making a total of 115,000 tons for this project alone.

The Milburn Lime and Cement works at Burnside, which are here shown in a photograph, have had an interesting history. The company was formed in 1888 and has manufactured cement since that date. Until the end of 1954 the company operated one cement manufacturing plant, producing 50,000 tons a year. Because of the expected needs of Roxburgh and a growing demand from the building industry in Otago, the company decided in 1949 to increase production and to install a further unit. A good deal of preliminary work was done by the company's own staff, but it was realised that in order to keep pace with the delivery of plant it would be necessary to employ contractors. Downer and Company, Ltd., of Wellington, who also have an important share in the construction of Roxburgh, were appointed to carry out the erection of buildings and installation of plant.

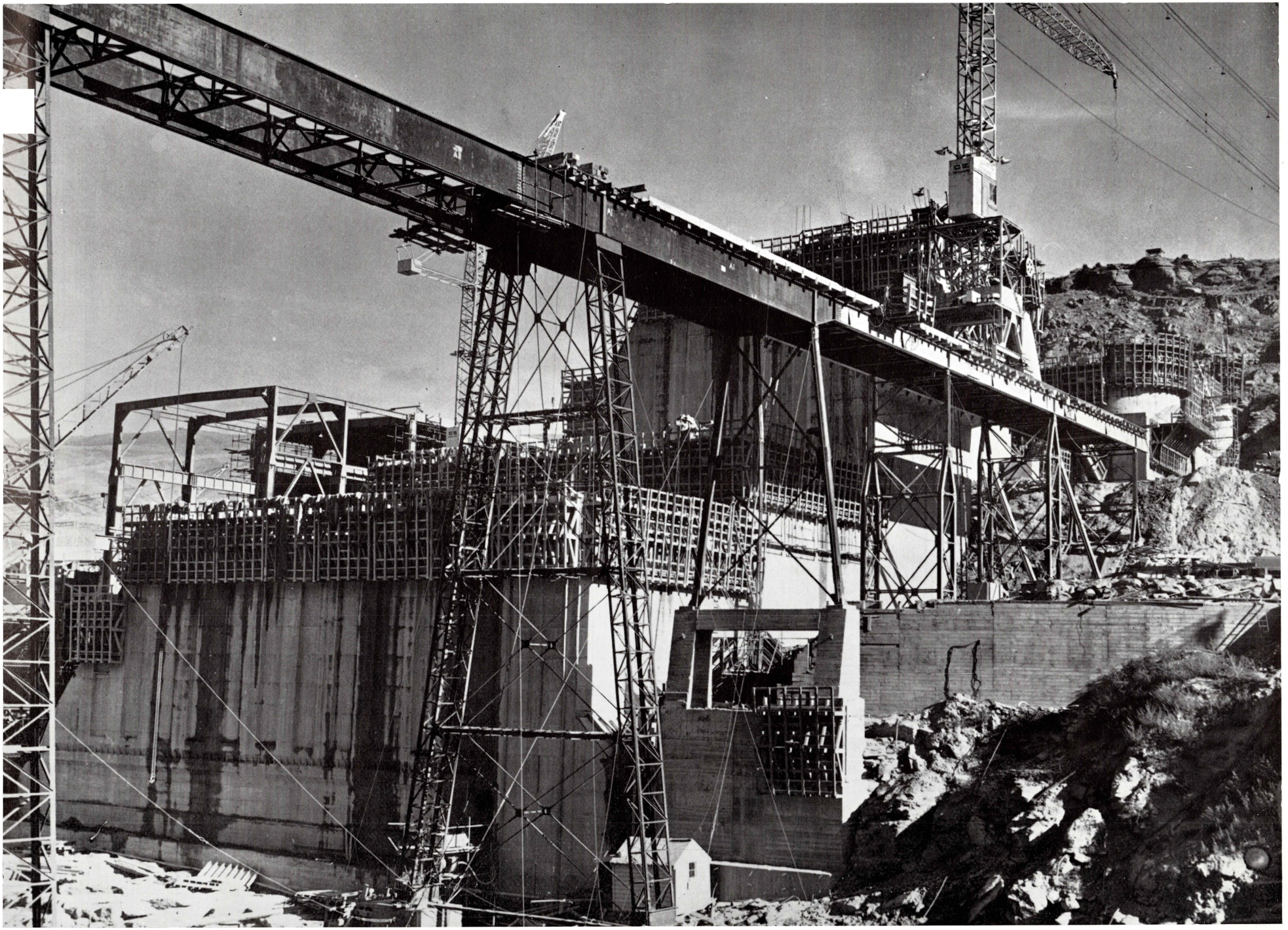
The second unit came into operation in January, 1955, and since then a considerable proportion of its output has gone to Roxburgh. The two units have a productive capacity of 110,000 tons of cement a year, which means that, if it could disregard the requirements of its customers in the building and other trades, the company could supply all the cement needed for Roxburgh in just over one year.



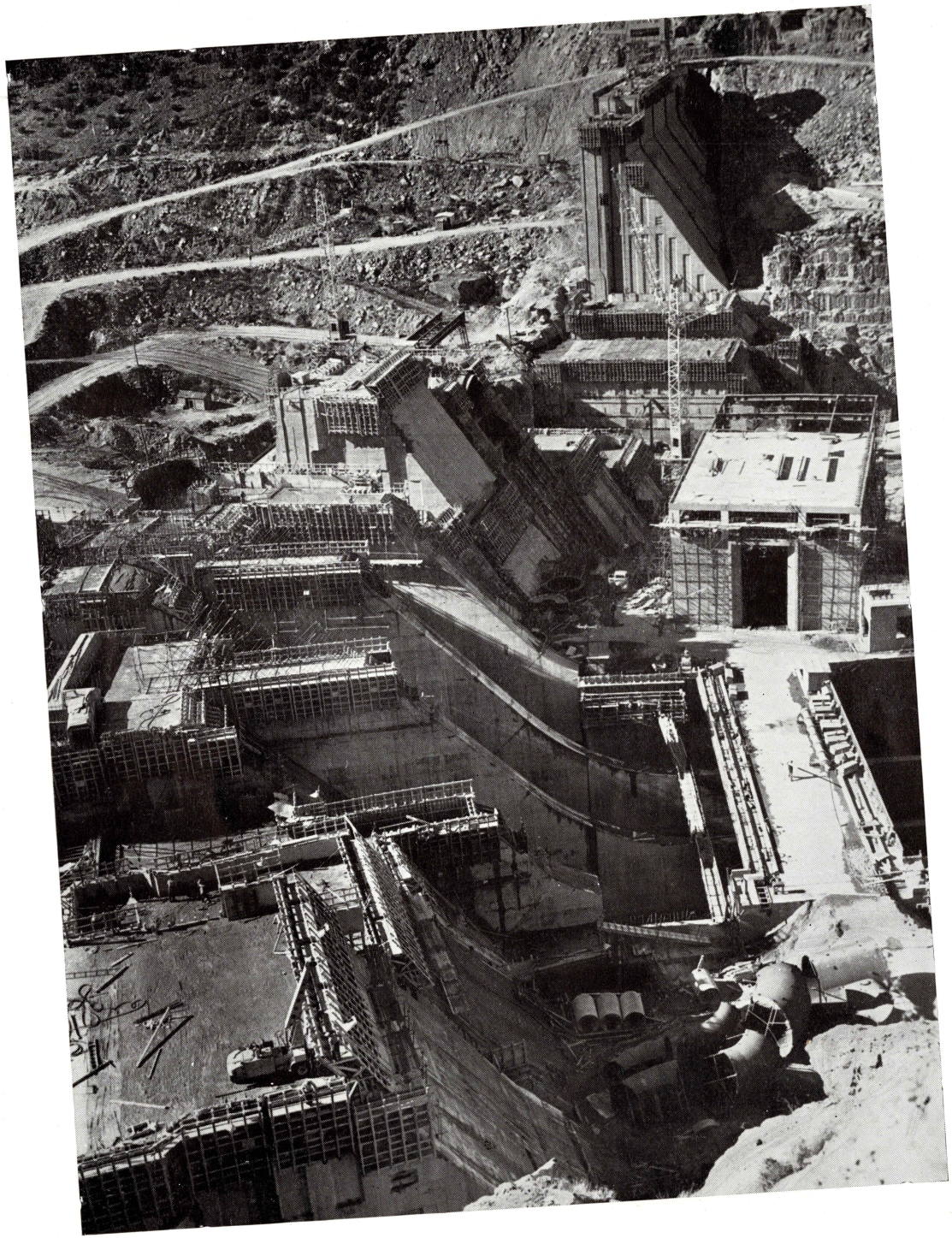
At the **intake of the diversion channel,** the massive curved piers will carry the vast weight of a section of the dam structure above. Just inside the entrance to the channel are grooves to take the iron gates which will be lowered to stop the flow of the river.



A VIEW FROM THE HIGH LEFT BANK looking down from behind the dam structure. On the downstream side the dam has a sloping face, but it will be vertically opposed to the pressure of the water on the other side.



THE BUILDING PERIOD offers endless possibilities of striking views. From ground level, this phctograph, which, like the one on the opposite page, was taken in **May, 1955,** shows temporary bridging raised high in the air to provide convenient access for the workmen and materials, and to run a crane.



Race Against Time

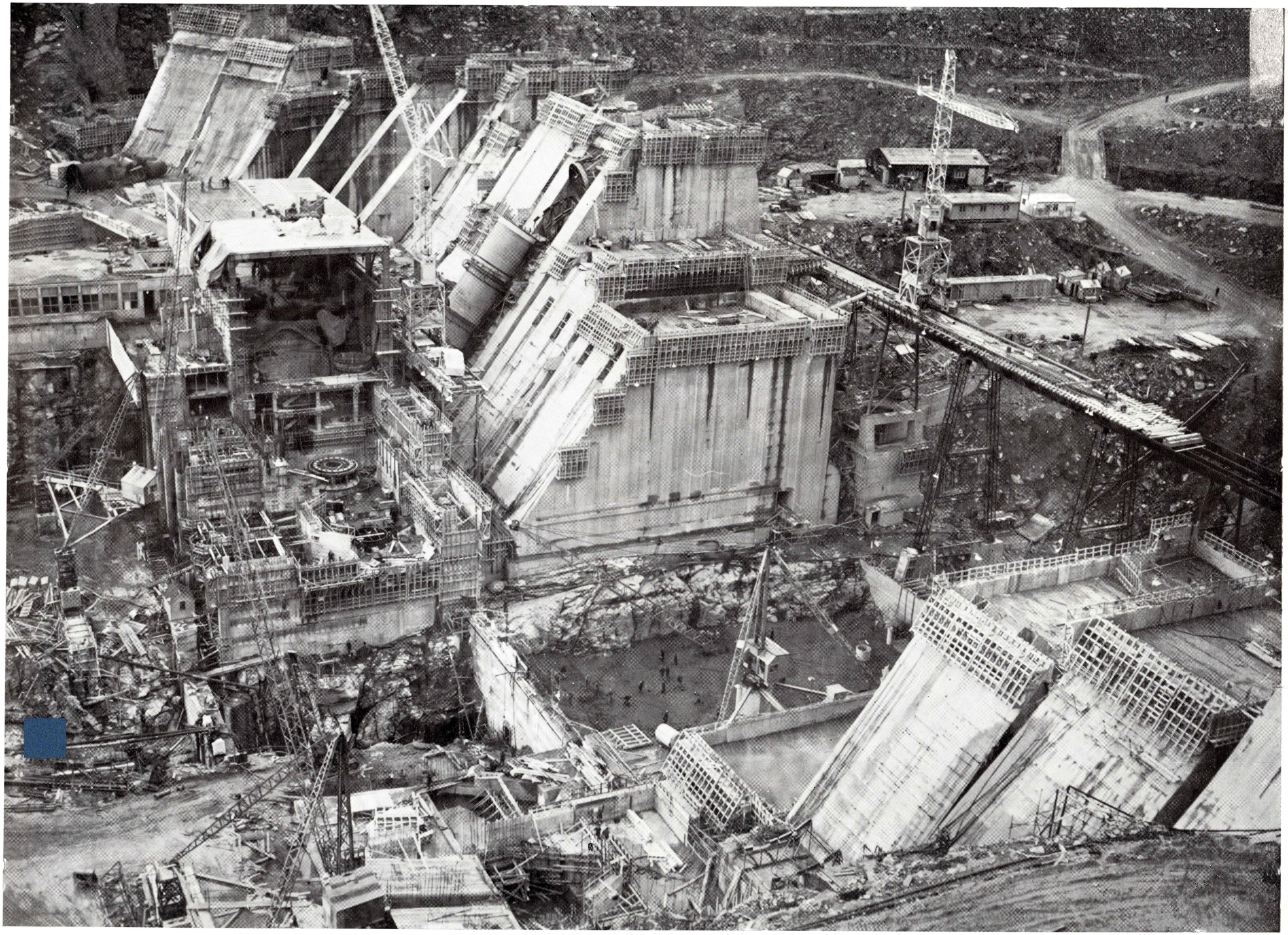
After the delays in the early stages of the project, the building of Roxburgh in 1954 and 1955 became a desperate race against time. The rate of construction was accelerated enormously and the contractors directed every effort towards earning a substantial bonus for completing the task ahead of schedule.

This called for co-ordination on a scale never previously attempted in New Zealand. It was essential to maintain a sufficient labour force on the job and in any works project on which up to 2,000 workers are engaged there is always a substantial turnover of manpower. The personnel office of the contractors had to keep the proportions of staff right as time could be lost if too many or too few workers of any particular classification were engaged.

A steady flow of material for the work has had to be provided. As much of this has been required from overseas, orders have had to be placed long in advance to ensure that requirements would be met irrespective of delays caused by overseas shipping strikes and other transport delays.

At least half of the output of the enlarged Milburn cement works has been regularly railed to Roxburgh. Reinforcing steel by the thousands of tons has been imported. At a later stage the generating equipment is being accumulated and assembled so that it will be ready to run as soon as possible after the dam is finished, the floodgates closed and the new lake filled. These are behind-the-scenes facts of the Roxburgh scheme which have provided object lessons in the fine art of constructional organisation.

LEFT.—The almost incredible rate of progress made in the project in **less than a year after the river was diverted,** is indicated by a comparison between this photograph, taken in May, 1955, with those on previous pages. At this stage concrete was being poured at the rate of 10,000 cubic yards a week and the half-way mark in concreting was rapidly approaching.



WITH THE DAM SECTIONS RISING STEADILY almost right across the river valley, good progress was also made with the construction of the power-house. In this photograph, taken in June, 1955, work was already well advanced for the housing of the first four generators. The gap in the structure near the foreground represented the original bed of the river, which had to be drained and excavated before building could proceed. It can be seen that concrete already fills that bed.

An impressive view, looking upstream, of the Roxburgh Hydro-Electric project. At the left top of the dam can be seen, above the spillway gates, the finished level over which a road will run. Immediately below the dam (centre) is the power house under construction and leading down to it can be seen the penstocks through which dammed-up water will flow to drive the turbines. At lower left is the electrical installation by which the power will be distributed. Extreme left above dam is well-known public observation point.

—White's Aviation Photograph.